

principal phenomenon as being more frequently and more readily observed than is the "second."

(b) *Twilight glow or Dämmerungsschein*.—The same remarks apply to the twilight glow which lies above the sun's position. As soon as the sun is several degrees below the horizon, however, the glow is no longer (or not yet) visible.

(c) *First twilight arch*.—The first twilight arch, the boundary of the first bright segment, lies in the west in the evening, in the east in the morning. It is visible when the sun stands below the horizon.

(d) *First purple light*.—The first purple light appears over the first twilight arch, in the evening it appears almost immediately after the disappearance of the first *Gegendämmerung*, while in the morning the reverse order occurs.

Civil twilight ends, in the evening, at the setting of the first purple light, and begins in the morning at the rise of the same.

First twilight is the name frequently applied to all the above phenomena from (a) to (d) collectively; in distinction to these is the series which follows under (e) to (g), known collectively as the *second twilight*.

(e) *Second anti-twilight or Gegendämmerung*.¹¹—The second anti-twilight begins, in the evening, in the eastern sky about the end of civil twilight; conversely in the morning it ends in the west at the beginning of civil twilight.

(f) *Second twilight arch*.—This arch, which forms the boundary of the second bright segment, appears in the evening after the setting of the purple light. In its initial stage it is simultaneously visible in the western sky with the first arch; the inverse condition occur in the morning.

(g) *The second purple light*.—The second purple light appears above the second twilight arch. In the evening it sinks behind, and in the morning it rises from behind that arch.

Astronomical twilight ends with the setting of the second twilight arch; in the morning this twilight begins with the rising of that arch.

MAIRAN'S DESCRIPTION OF ANTI-TWILIGHT.

Elsewhere in this issue reference is made¹ to the first published description of twilight phenomena where the dark segment and the first anti-twilight arch—as observed in the east on a good day soon after sunset—are given their present names. This description was by Mairan, who published it in a somewhat inaccessible work² that happens to be in the Weather Bureau library. It also contains a reference to what is perhaps the earliest printed mention of the phenomena.

We reprint the French passages with a translation; our French version follows the original closely, except in capitalization and in the use of the sign "&". A marginal reference in the original is here given as a footnote, and * * * indicate omissions of passages not bearing on the description proper.—C. A. Jr.

XII^{me} ÉCLAIRCISSEMENT.

Sur l'Anticrépuscule.

Qu'il me soit permis, pour abréger, de nommer ainsi un phénomène qui ne manque presque jamais de paraître dans les jours sereins avec le crépuscule, et qui lui est

opposé, non seulement par le lieu du ciel qu'il occupe, mais encore par le renversement de sa partie lumineuse, d'autant moins vive qu'elle est plus près de l'horizon.

Il ne faut que regarder le ciel un peu avant le lever du soleil, ou quelques minutes après son coucher, pour reconnoître le phénomène ou le météore dont il s'agit. Il est très-visible, et vrai-semblablement aussi ancien que le monde; et il y a tout lieu de s'étonner, qu'il n'en soit pas parlé davantage dans les livres de physique ou d'astronomie, tant anciens que modernes. Je n'en connois qu'un où il en soit fait mention expresse, et qui fut imprimé à Ulm en 1716, ayant pour titre *des Couleurs du Ciel*.³ M. Cramer, qui avait très-bien remarqué l'anticrépuscule, et qui avoit même fait quelques recherches d'optique sur ce météore, s'étonnoit comme moi du silence des auteurs à cet égard. Il m'en écrivit il y a plusieurs années, et je lui communiquai ce que j'en savois, avec la note du livre de Funcius. D'autres occupations l'empêchèrent sans doute de pousser plus loin ses recherches, ou de les publier. Heureux, si je pouvois encore consulter sur ce sujet, comme sur toute autre matière, un ami si fidèle, si sage si éclairé, et dont je regretterai éternellement la perte. *

On remarquera donc le soir d'un beau jour, au coucher du soleil, par exemple, ou quelques minutes après, à la partie opposée du ciel et immédiatement sur l'horizon, une espèce de bande ou de *Segment obscur*, bleuâtre et pourpré, surmonté d'un *arc lumineux* et coloré, blancheâtre, orangé, et enfin couleur de rose à son bord supérieur, tirant quelquefois sur la couleur de feu. Car ces couleurs, ou plutôt ces nuances des couleurs vraies n'y sont jamais ni bien tranchées ni bien décidées. Ce n'est aussi que par des circonstances plus ou moins favorables, selon que l'air est plus ou moins dégagé de vapeurs, d'exhalaisons et de nuages, que l'anticrépuscule d'un jour, ou d'un climat, diffère de celui d'un autre. Du reste, rien n'est plus uniformément constant que ce phénomène, qui est purement optique, et en cela bien différent de l'aurore boréale, dont le sujet est physique, mais variable et accidentel. *

Cependant le soleil s'enfonce encore sous l'horizon, le crépuscule s'abaisse, et l'anticrépuscule s'élève d'autant; les rayons du soleil qui alloient frapper la voûte au zénit ou près du zénit n'y parviennent plus, ils se réfléchissent sur des points plus proches du soleil, et l'anticrépuscule s'élève encore; son arc lumineux et coloré se détache du segment bleuâtre et pourpré, qui ne demeure bien-tôt que gris ou cendré, il monte toujours et parvient enfin jusqu'au zénit, où il est encore sensible lorsque l'air y est pur; car après être monté jusqu'à une certaine hauteur, il s'affaiblit de plus en plus, et disparaît enfin totalement. J'ai observé l'anticrépuscule une infinité de fois dans les parties les plus méridionales de la France, à Paris et aux environs.

La bande bleuâtre et pourprée de l'horizon ne demeure plus que grise et cendrée, lorsque l'arc anticerépusculaire⁴ s'en est détaché, parce que les rayons rouges du soleil et de la partie la plus brillante du crépuscule ne s'y réfléchissent plus. *

[Translation.]

On the anti-twilight or anticrepuscule.

Permit me, for the sake of brevity, to thus name a phenomenon that almost never fails to appear on fine days (jours sereins) at twilight, and which is opposite to this latter not only as to location in the sky but also

¹¹ This term includes the second eastern twilight arch (at sunset) western at sunrise, and the second dark segment.—C. A. Jr.

¹ Von Bezold's description of twilight, p. 621.

² Mairan, [Jean Jacques Dortous] dc. Traité physique et historique de l'aurore boréale. Seconde édition, Revue, & augmentée de plusieurs éclaircissements. Paris, Imprimerie royale, (1754). (Suite des Mémoires de l'Académie Royale des Sciences, Année M.DCCXXXI.) (xlii, 570, xxii p. 17 pl. 254 cm. pp. 400-403.

³ Funcius, Joh. Cusp. De coloribus cœli. Ulm, 1716. Sect. IV, §xx.

in the reversed position of its luminous portion, decreasing in brightness as the horizon is approached.

One need but to observe the sky a little before the rising of the sun, or a few minutes after it has set, to recognize the phenomenon or meteor⁴ with which we are concerned. It is very plain, and probably as old as the earth itself; and there is every reason for astonishment that it does not receive more attention in both the modern and ancient works on physics or astronomy. I know of but one work where it is expressly mentioned, and that is a work entitled "On the Colors of the Sky": M. Cramer—who had indeed well observed the antcrepuscule and had even made some optical studies on it—was as surprised as I at the silence of writers in this respect. A number of years ago he wrote to me on the subject, and I communicated to him what I knew thereof together with the note on the work by Funccius. No doubt other occupations prevented him from carrying his researches farther, as well as from publishing them. Happy would I be might I still consult on this, and all other subjects, a friend at once so faithful, so wise, so enlightened and whose loss I shall eternally regret. * * *

On the evening of a fine day, then, one will observe at sunset or a few minutes after, in that portion of the sky opposite the sun and immediately on the horizon, a kind of band or *dark segment* of bluish and purple color surmounted by a *luminous* and colored *arch* which is whitish, orange, and finally on its upper border of a rose color sometimes verging on fire color. For these colors, or rather these shades of true colors are never well, clearly, or sharply defined here. Also, it is only under more or less favorable circumstances, according as the air is more or less free from vapors, exhalations, and clouds, that the antcrepuscule of one day or of one climate differs from that of another. Otherwise there is nothing more uniformly constant than this phenomenon, which is a purely optical one; therein quite different from the aurora borealis which belongs to physics but is variable and accidental. * * *

Now as the sun sinks below the horizon, the twilight or crepuscule sinks, and the [anti-twilight or] antcrepuscule rises by a corresponding amount; those solar rays that had been striking the vault at or near the zenith no longer reach so far, they are reflected from points nearer the sun, and the anti-twilight continues to rise; its luminous, colored arch detaches itself from the bluish, purple segment which soon shows nothing but a gray or ash shade, it [the colored arch:] mounts steadily and finally comes to the zenith where it is still visible when the air is there clear; for after having attained a certain elevation it grows weaker and weaker, until at last it totally disappears. I have observed the anti-twilight innumerable times in the more southern portions of France, at Paris, and in its environs.

The bluish and purple band at the horizon becomes gray and ash-colored when the anti-twilight or antcrepuscular arch⁵ detaches itself therefrom, because the red rays from the sun and from the more brilliant portion of the twilight (crépuscule) no longer are reflected so far downward.

(The author also remarks that while the secondary rainbow is frequently observed, he is not aware that a secondary anti-twilight arch has ever been seen.—C. A., Jr.)

EXPLANATIONS OF THE WESTERN PURPLE LIGHT AND THE EASTERN AFTERGLOW (NACHGLÜHEN).¹

By ALBERT HEIM.

[Translated for the MONTHLY WEATHER REVIEW by C. Abbe, Jr.]

All observations of the phenomenon point to the conclusion that the western purple light (Westpurpur) is the condition necessary for the afterglow (Nachglühen). If the western purple light does not appear, then the afterglow in the east is always absent; and if the western purple light is very weak, then one sees hardly a weak suspicion of the afterglow.

Wolf, who was the first to study the alpenglow with exactness, reached the conclusion—which is confirmed by Maurer—that the evening glow of the western sky, which we see projected into the high air layers as the western purple, was reflected at a sharp angle from the mirroring undersurfaces of high air layers. Mirror reflection does not essentially change the color of the light falling upon the mirror, but the width of the effective surface and the breadth of the bundle of rays prevents the production of sharp shadows. Therefore, a portion of the evening red (Abendrot) is reflected downward once more into the blue earth shadow. If this is the manner in which the afterglow originates, then the name "reflex glow" (Spiegelglühen) is justified.

If the afterglow (Nachglühen) is a reflex glow, then we may compute the altitude of the mirroring air layers. The results give altitudes of only 20 to 35 km. for the afterglow at a solar depression of 4° to 6°, and of 70 to 80 km. for a depression of 9°. The different phases of the afterglow correspond to mirroring layers at different heights.

It seems to me that the following explanation of the afterglow is also a possible one:

The upper air layers receive almost solely yellow-red, they are directly illuminated by the yellow-red. The air reflects diffusely not simply blue *alone*, but all colors, as is shown by the whitish appearance along the horizon; however, it reflects more of blue than of the other components of white light. If it receives yellow-red almost exclusively, then it must also reflect diffusely the yellow-red, of course weakened. Thus there originates throughout the whole zone of air standing in the earth's shadow a *diffuse evening red* (Abendrot) *below the directly illuminated evening red*. This is at one and the same time the purple light in the west and the afterglow in the east. In the purple light we see nothing other than the higher air layers illuminated by the evening red from the sun. Yellow-red illumination of the air appears as purple-red. And the afterglow in the east is the reflection (*Widerschein, Reflex, Abglanz*) of the western purple.

Finally, there is support for the probability that diffraction affects the light rays shining down to us from the higher and still directly illuminated air layers at the time of the purple light and the afterglow. Kiesling, Pernter, and Rigganbach, particularly have assumed that diffraction was the cause of the western purple light. According to Rigganbach's observations after the eruption of Krakatoa it was very clear that the purple light resulted from the widening of Bishop's Ring, which latter certainly owed its copper-red-brown to the light's diffraction by dust particles. It seems to me that mirror-reflection and diffuse reflection send the light down to us

⁴ I. e., "Any phenomenon or appearance in the atmosphere," the first significance of the word.—Transl.

⁵ It is interesting to note here that Mafran uses the name "anti-twilight arch" not less than 4 times in this Eclaircissement.—Transl.

¹ Heim, Albert. *Luft-Farben*. Hofer & Co. A.-G., Zürich, 1912. 8 cm. pp. 70-74. [Notable illustrations in color!]